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WILLISTON, H. L.

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July 1964

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ESTABLISHMENT REPORT

THE EFFECT OF PINE PLANTATION MANAGEMENT ON RUNOFF AND SEDIMENT PRODUCTION

Coffeeville Watersheds

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6200-7

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July 1964
Establishment Report Summary
H. L. Williston

THE EFFECT OF PINE PLANTATION MANAGEMENT ON RUNOFF AND SEDIMENT PRODUCTION

Pine plantations, originally established to control erosion, are now being thinned for pulpwood. Very little is known about what the effect of thinning these plantations will be, hydrologically speaking. This report covers the details of establishment of a study in which pine plantations will be eventually thinned back to several densities to determine the effect of thinning on surface runoff and sediment production.

The objectives are:

1. To determine, during a suitable calibration period, the rates and amounts of surface runoff and soil loss from five small watersheds in pulpwood-size plantations on erosive soils.

2. Following calibration to determine the effect of cutting the five units to various stand densities on runoff and sediment production.

3. To provide demonstration areas for public observation of cutting effects on runoff and erosion.

The five watersheds are 4 to 7 acres in extent. Both loess and Coastal Plain soils are represented. The watersheds were planted with loblolly and slash pine in 1940 and 1941. After one or two thinnings they now have from 69 to 83 square feet of pine basal area and 12 to 15 cords of pine pulpwood. There is little undergrowth. Weight of the forest floor ranges from 7 to 9 tons per acre.

Three-foot H-flumes and ADR recorders have been installed. Cost of installation, exclusive of technical time and labor, was $12,938. Approximately a quarter of this went for bringing electric power to the flume sites.

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ESTABLISHMENT REPORT

THE EFFECT OF PINE PLANTATION MANAGEMENT ON RUNOFF AND SEDIMENT PRODUCTION

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HLW:ssk
1 + 7

Frontispiece.--Three-foot H-flume and recorder on Watershed No. I.

CONTENTS

	Page
Introduction	1
Cooperation	1
Objectives	1
Details of establishment	2
The study areas	2
Location	2
Ownership	2
Watershed maps	2
Soils	3
Vegetation	6
Pole-timber inventory	6
Lesser vegetation inventory	12
Forest floor sampling	14
Timber stand improvement	18
Flume installation	18
Sediment sampling	20
Rainfall measurements	20
Installation schedule	21
Cost of establishment	22
Appendix	23

INTRODUCTION

Pine plantations, originally established to control erosion, are now being thinned for pulpwood. Very little is known about what the effect of thinning these stands will be, hydrologically speaking. This report covers the details of establishment of a study in which pine plantations will be eventually thinned back to several densities to determine the effect of thinning on surface runoff and sediment production. From the information obtained it is our hope that guidelines for the management of pine plantations on erosive watersheds can be developed.

COOPERATION

This study was installed with the financial assistance and cooperation of the Yazoo-Little Tallahatchie Flood Prevention Project.

OBJECTIVES

This study has three objectives:

1. To determine, during a suitable calibration period, the rates and amounts of surface runoff and soil loss from five small watersheds in pulpwood-size pine plantations on erosive soils.

2. Following calibration, to determine the effect of cutting the five units to various stand densities on runoff and sediment production.

3. To provide demonstration areas for public observation of cutting effects on runoff and erosion.

DETAILS OF ESTABLISHMENT

The Study Areas

Location

The five watersheds are located in Sections 29 and 33, T25N, R6W in Yalobusha County on the Grenada Division of the Oxford Ranger District. Three of the watersheds lie east of the Coffeeville Fire Tower and two of them lie to the west. All-weather gravel roads skirt the upper rims of all five watersheds. A small earthen dike has been constructed completely around each watershed. This not only defines the areas but eliminates road water in some instances. Four culverts have also been installed to divert the road water.

Ownership

The watersheds are located on land belonging to the Holly Springs National Forest which is administered as part of the Mississippi National Forest. The Forest Supervisor has granted a letter of authorization covering the use of this area for research purposes.

Watershed Maps

Plane table maps were drawn of the five watersheds. Copies of these maps are in the Appendix. They show the boundaries, contours, gullied areas, drop box and flume location, and the turning points used in the topographic survey. Watersheds IV and V are the most severely gullied.

Watershed areas were determined using a polar planimeter on the plane table maps which were drawn with a scale of 1 inch equals 100 feet (I, II, and III) or 1 inch equals 50 feet (IV and V). The drainage areas for the five watersheds are as follows:

Watershed	Area in acres
Coffeeville Number I	6.95
Coffeeville Number II	4.77
Coffeeville Number III	5.91
Coffeeville Number IV	4.06
Coffeeville Number V	3.67
Average	5.07

Soils

The soil series, types, and phases found on the five watersheds were identified and mapped by Frank Scott of the Charleston office of the Soil Conservation Service. The soil maps are in the Appendix.

The acreage of the five watersheds by soil series and percent of total acreage are as follows:

Watershed No. I	Acreage	Pct. of total
Providence	2.81	40.43
Memphis	1.79	25.82
Loring	1.72	24.73
Falaya	0.63	9.02
Total	6.95	100.00

Watershed No. II		Acreage	Pct. of total
Loring		4.29	89.98
Memphis		0.32	6.62
Falaya		0.16	3.40
	Total	4.77	100.00

Watershed No. III		Acreage	Pct. of total
Ruston		3.77	63.84
Providence		1.80	30.46
Collins		0.28	4.72
Memphis		0.06	0.98
	Total	5.91	100.00

Watershed No. IV		Acreage	Pct. of total
Ruston		3.55	87.39
Providence		0.45	11.21
Ochlockonee		0.06	1.40
	Total	4.06	100.00

Watershed No. V		Acreage	Pct. of total
Ruston		3.39	92.32
Providence		0.25	6.88
Ochlockonee		0.03	0.80
	Total	3.67	100.00

A brief description of the soils encountered and the legend used on the soils maps follows:

Soil series	Description
32	Ruston sandy loam, deep well-drained upland Coastal Plain soil.
31	Providence silt loam, moderately deep thin loess upland soil with a fragipan about 24 inches deep. (Loess cap over sand)
30	Loring silt loam, moderately well to well-drained loess upland soil with a weak fragipan about the 30-inch depth.
20	Memphis silt loam, deep well-drained upland loess soil.
10	Collins silt loam, moderately well-drained loess bottomland soil.
43	Falaya silt loam, somewhat poorly-drained loess bottomland soil.
12	Ochlockonee fine sandy loam, well-drained Coastal Plain bottomland soil.

The six slope classes used were:

A -- 0-2 percent

B -- 2-5 percent

C -- 5-8 percent

D -- 8-12 percent

E -- 12-17 percent

F -- 17-28 percent

The erosion classes used were:

1. Slight--less than 1/4 topsoil gone

2. Moderate--1/4 to 3/4 topsoil gone, may include a few gullies

3. Severe--3/4 topsoil to 1/4 subsoil gone, may include several gullies

4. Used on bottomland soils

Vegetation

The watersheds were planted with loblolly and slash pine in 1940 and 1941 on abandoned cropland which had been severely eroded. Watersheds #I and #II have been thinned twice for pulpwood, the last time during the winter of 1962-63 to salvage ice damage. Watersheds #III, #IV, and #V have been thinned once for pulpwood about 3 years ago.

Pole-Timber Inventory

A 100-percent inventory of all the trees in the 2-inch d.b.h. class and larger was made on each watershed during the winter of 1963-64. Calipers were used. Trees were tallied by species groups on the tally form in figure 1. A separate tally was kept for slash pine but loblolly and shortleaf (volunteer stocking) were tallied together.

Stand and stock data per acre on the five watersheds are summarized in table 1. The cubic volume table used was adopted from Mesavage[1/] and is included in the Appendix as table 6. The number of stems per acre of pine and hardwood are shown by d.b.h. class in tables 2 and 3 respectively.

1/ Mesavage, Clement. 1947. Tables for estimating cubic-foot volume of timber. Occasional Paper 111, Sou. For. Exp. Sta., 70 pp.

Figure 1

FS-SO-1604-1.2 Pole-timber Tally

Watershed _____ Treatment _____ By _____ Date _____

D. B. H.	Pine											White oaks	Red oaks	Hickory	Gums	Other
In.	5'	10'	15'	20'	25'	30'	35'	40'	45'	50'	55'	Number				
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																

Table 1.--Summary stand and stock data per acre by watersheds

Item	Watershed number				
	I	II	III	IV	V
Pine basal area[1]--sq. ft.	68.9	70.2	71.3	83.1	81.8
Hardwood basal area[1]--sq. ft.	2.4	1.6	9.7	8.2	17.7
Pine trees 4" plus--number	162.4	176.9	232.0	236.5	270.5
Hardwood trees 4" plus--number	14.8	10.7	53.1	27.7	61.0
Pine cubic volume 5" plus--cu. ft.	1121.7	1113.0	874.0	1137.9	1027.4
Pine cubic volume 5" plus--cords[2]	15.0	14.8	11.7	15.2	13.7

1/ 4 inches d.b.h. and larger

2/ 75 cubic feet per cord

Table 2.--Pine stand per acre

D.B.H. (inches)	Watershed number				
	I	II	III	IV	V
	No. of trees				
2	0.6	2.3	20.5	9.6	44.1
3	3.7	6.1	29.3	13.1	38.7
4	9.2	13.2	34.2	16.7	45.5
5	9.2	16.1	28.9	26.6	36.2
6	8.2	11.3	33.3	31.3	43.6
7	17.8	17.8	36.0	35.7	37.1
8	28.8	31.4	33.7	33.5	33.8
9	33.1	34.0	28.8	39.2	31.1
10	28.8	25.4	19.5	29.6	21.5
11	15.4	17.6	9.6	14.8	12.3
12	8.6	7.5	5.2	5.9	5.4
13	2.4	1.9	1.9	2.5	3.0
14	0.9	0.4	0.5	0.7	0.8
15					
16			0.3		
17					
18					
19					0.3
20					
	166.7	185.0	281.7	259.2	353.4

Table 3.--Hardwood stand per acre

D.B.H. (inches)	Watershed number				
	I	II	III	IV	V
	No. of trees				
2	65.9	37.1	66.8	48.3	53.4
3	20.3	13.8	38.7	18.2	31.1
4	9.1	4.8	23.4	9.9	16.3
5	3.9	3.1	12.1	5.4	9.8
6	.7	1.7	7.6	5.4	8.2
7	.1	.2	4.9	2.7	8.2
8	--	.4	1.2	2.0	5.7
9	.1	--	.8	1.2	3.8
10	.1	.4	1.9	.5	2.5
11			.5	1.7	2.2
12			.2	.2	1.6
13			.2	.7	.8
14				.7	.5
15					.8
16					
17					
18					.3
19				.2	
20			.2		.3
21					
22			.2		
	100.2	61.5	158.7	97.1	145.5

Pine basal areas on the first three watersheds are remarkably similar. The higher basal area on No. IV and No. V reflects the fact that they have been thinned only once. On watershed No. I, 80 percent of the pine basal area is slash pine; on watershed No. II, 62 percent; and on watershed No. III, 29 percent. Watershed No. III has quite a bit of volunteer shortleaf along the northern and western rims.

Watersheds No. I and No. II have almost no hardwoods; on the others a tenth or more of the basal area is in hardwood. If the 4-inch and larger pines were evenly spaced over the watersheds those on No. I and No. II would be spaced 16' x 16'; those on No. III and No. IV would be 14' x 14' and those on No. V, 11' x 15'. Cubic volumes in pine 5 inches d.b.h. and larger are quite similar with the volume on No. III reflecting the smaller size timber.

There are very few 2- and 3-inch pines on No. I and No. II but No. IV has 23 small pines per acre; No. III, 50 per acre; and No. V, 83 per acre. These data are indicative of the smaller size tree stocking the gullied areas.

The hardwood stand is of small size on No. I and No. II but there is a scattering of larger hardwoods on Nos. III, IV, and V--many of which antedate the planting of pine. Most of the hardwoods are concentrated along the drains except on No. III where there is a lot of blackjack oak along the northwestern edge.

Lesser Vegetation Inventory

Each watershed was divided in the office on paper into blocks by "staking" block centers 112 feet apart on lines 97 feet apart running east and west so that each "stake" represented the center point of a quarter-acre hexagon. Block centers were located on the watershed maps by means of a gridded template.

From the block centers plotted on each watershed ten were randomly selected for sampling and located in the field with respect to the survey turning point stakes. Two sample plots, mil-acre in size, were randomly located within each of the ten blocks. Each sample was located along a randomly selected azimuth (0-360°). Plot locations on the azimuths were determined by selecting random numbers from 0-44 (the radius of the circle inscribed in the hexagon is 56 feet); or from zero to a number minus 12 (the number representing the distance in feet to the watershed boundary). These numbers represent the distance in feet from the block center to the sample point center which was marked with an iron stake. Directions as to how to find these lesser vegetation sampling plots can be found in tables 7, 8, 9, 10, and 11 in the Appendix.

All woody vegetation from 6 inches tall to 0.50 inch d.b.h. and all pine reproduction of this size and smaller were tallied in March 1964 by species groups on a circular mil-acre plot (radius 3.73 feet) around the sample plot center. The form in figure 2 was used for this. These mil-acres were numbered 1 and 2 in a clockwise direction around the stake.

Figure 2

FS-SO-1604-1.2 Small Vegetation Tally

Watershed _____ Treatment _____ By _____ Date _____

Mil-acre No.	Pine	White oaks	Red oaks	Hickory	Gums	Other	Shrubs	Herbaceous	1/100 acre No.	Pine	White oaks	Red oaks	Hickory	Gums	Other	Shrubs
Total																
Total per acre																

Woody vegetation in the one-inch d.b.h. class was tallied on a one-hundredth-acre plot (radius 11.78 feet) with the same center as the mil-acre plot. The percent of the area occupied by grass or other herbaceous vegetation on each milacre was determined by stretching a measuring tape along the four cardinal radii and recording the linear inches of herbaceous material directly under the tape at its ground line intersection.

Tables 4 and 5 show the number of stems per acre and the stocking of the small stems. There really aren't very much reproduction or small saplings of any sort present. The stands are fairly open in appearance. We do have a good catch of pine seedlings from last fall's seed crop which our inventory doesn't show. Herbaceous material covered 2% of the area on No. I, 3% on No. II, 1% on No. III, 1% on No. IV, and 1% on No. V.

Forest Floor Sampling

At the southern edge of each numbered mil-acre a sample of the forest floor was collected at the time of the vegetational survey. A frame of angle iron 0.96 foot square was used. The L, F, and H layers were collected by cutting along the inside of the frame with a knife. Depth of the forest floor was measured to the nearest tenth-inch after cutting and before placing the sample in a paper bag. Undecomposed grass was excluded from the sample. Sticks less than 1/4 inch in diameter and small chunks of bark were included in the sample.

Table 4.--Number of small stems per acre

Watershed	0.5" tall to 0.5" d.b.h.							1" d.b.h. class						
	Pine	White oaks	Red oaks	Hickory	Gum	Other	Shrubs	Pine	White oaks	Red oaks	Hickory	Gum	Other	Shrubs
Number	Number							Number						
I	100				350	1350	250					40	210	
II	400				300	850						30	90	
III	100				100	500	300		15	10	5	40	50	
IV	150				100	650	200	5	10				40	5
V	250		50		1000	450	100			35		5	15	105
Average	200		10		190	760	170	1	5	9	1	23	81	22

Table 5.--Stocking of small stems

Watershed	0.5" tall to 0.5" d.b.h.							1" d.b.h. class						
	Pine	White oaks	Red oaks	Hickory	Gum	Other	Shrubs	Pine	White oaks	Red oaks	Hickory	Gum	Other	Shrubs
Number	Percent							Percent						
I	10	--	--	--	5	40	15	--	--	--	--	25	80	--
II	30	--	--	--	10	30	--	--	--	--	--	25	45	--
III	5	--	--	--	10	20	10	--	10	10	5	10	35	--
IV	10	--	--	--	10	30	10	5	5	--	--	--	25	5
V	15	--	5	--	35	35	10	--	--	25	--	5	15	25

The forest floor samples were air dried in the laboratory and the mineral matter and small bits of organic matter screened out. The powdery mixture obtained was weighed, dried in an oven at 105° C., and reweighed after burning in a muffle furnace. The bulk of the forest floor sample was dried in an oven at 105° C. and weighed. Then the oven-dry weight of the forest floor was obtained in pounds per acre by adding the weight in grams lost on ignition to the weight in grams of the bulk litter and multiplying by 100.

The weights of the forest floor in tons per acre were:

Watershed Number	Mean Tons	Standard Deviation Tons
I	9.05	± 1.19
II	7.60	± 1.42
III	7.32	± 1.44
IV	7.24	± 1.94
V	8.11	± 2.13

The standard deviations increased slightly on watersheds IV and V where several of the lightly covered gullies were sampled. Average litter depth was 0.70 inch on No. I, 0.67 inch on No. II, 0.64 inch on No. III, 0.62 inch on No. IV, and 0.74 inch on No. V.

The percent of each of the numbered mil-acres covered with litter was estimated. Average cover by watersheds was: No. I--100%; No. II--93%; No. III--93%; No. IV--82%; and No. V--99%.

Timber Stand Improvement

The hardwoods 1 inch d.b.h. and larger were deadened on March 23 and 26, 1964 using a total of 7-1/2 gallons of 2-4D in metered Jim-Gem injectors. The average man-hours expended on the watersheds were: No. I--5 man-hours; No. II--1-1/2 man-hours; No. III--7-1/2 man-hours; No. IV--4-1/2 man-hours; and No. V--8-1/2 man-hours.

Flume Installation

The rate and volume of storm runoff is measured with the 3.0-foot, H-type flume. The flumes are of riveted sheet metal construction and were manufactured by the Memphis Sheet Metal Works, Inc., according to the specifications and plan shown in Figure 10, Page 25 of SCS-TP-51, "Devices for measuring rates and amounts of runoff." The floor of the flume was modified by using 1/4-inch sheet steel rather than the 16-gauge galvanized metal originally specified.

The 3-foot, H-type flume is sensitive to flows of a 0.02-foot head (0.0021 cfs.) through the aperture. Its maximum capacity is 30 cfs. which is more than enough to handle prospective flows.

Work on the construction of the flume installation was started in May 1963 and finished, for the most part, in June. Some "touching up" of the installation continued through the fall and early winter.

The Analog-to-Digital Recorder, manufactured by the Fischer and Porter Company was installed at each flume site to maintain a continuous record of the depth of water flowing through the flume. These recorders

require AC power in order to punch out on tape at 2-minute intervals the head of water flowing through the flume. Approximately 1.5 miles of power line was constructed by the Tallahatchie Valley Electric Power Association of Batesville, Mississippi in order to bring electricity in to the sites.

The tapes are taken to the office for editing, i.e., cutting out the unused portions. Those portions of tape recording a water stage are sent to the Fischer and Porter Company for translation of the data to IBM cards. The Station Statistician is developing a computer program. Once this is done the cards can be run through a 1620 computer to give runoff by storm, season, or year.

A reinforced concrete approach section was installed to provide firm anchorage for the flume and to ensure orderly delivery of the runoff to the flume. The approach section also facilitates the measurement of sediment. Plans for the approach section follow the general specifications shown on page 31 of SCS-TP-51. An open-end concrete block box was constructed to serve as a support for the forward end of the flume, preventing undercutting below the flume. This box contains and supports the sediment sampler.

All construction was done by Oxford Research Center personnel. We had hoped to commence operations on October 1, 1963. The Fischer and Porter Company, however, was slow in delivering the ADR recorders and one of them ran only 14 hours before breaking down. Its replacement was also slow in arriving. Hence it was December 7, 1963 before Watersheds No. I, No. II, No. IV, and No. V were operating. The first runoff was recorded on January 6, 1964. Watershed No. III went into operation on January 19, 1964.

Sediment Sampling

The Coshocton sediment sampler is used to collect samples of runoff during periods of flow. The samplers are manufactured locally in accordance with detailed working plans on file at the Oxford Research Center. Sediment samples are collected in quart bottles after each storm to facilitate the relating of sediment production to storm size and intensity.

The samplers were initially connected to two barrels with a 10-hole divisor between the first and second barrel. Several of the second barrels overflowed, necessitating the addition of a second 10-hole divisor and a third barrel. Then the third barrels started washing out. To overcome this problem the third barrel was eliminated and a 50-hole divisor installed between the first and second barrels. These divisors are now set in concrete in order to keep them level at all times.

Rainfall Measurements

Three recording rain gages are being used to provide a continuous record of precipitation amounts and intensities for individual storms. One of these gages is between the No. I and No. II flume sites, one near the No. III flume site, and one between the No. IV and No. V flume sites. All are in openings created by cutting the power line right-of-way.

Seven standard rain gages complement the recording rain gages. Three of these are on watersheds No. I and No. II, two on watershed No. III, and two on watersheds No. IV and V. Thus each general area is equipped with at least three rain gages. These gages are serviced after every rain.

Installation Schedule

Located watersheds	March 1963
Letter of Authorization received from Forest Supervisor permitting use	April 1963
Contract let for construction of H-type sheet metal flumes	April 1963
Contracted with Tallahatchie Valley Electric Power Association for power line construction	May 1963
Ordered ADR recorders, rain gages, sediment samplers, etc.	May 1963
Constructed approach sections and installed flumes	May 1963
Installed Coshocton sediment samplers	June 1963
Mapped watersheds	August, September 1963
Power line constructed	September 1963
Installed first recorder (immediately broke down)	September 1963
Soil survey	December 1963
Installed four recorders	December 1963
Inventoried trees 2" d.b.h. and larger	December 1963, February 1964
Installed one recorder (all five watersheds in operation)	January 1964
Inventoried lesser vegetation and litter	March 1964
Timber stand improvement	March 1964
Remodeled sediment sampler divisors	May 1964

COST OF ESTABLISHMENT

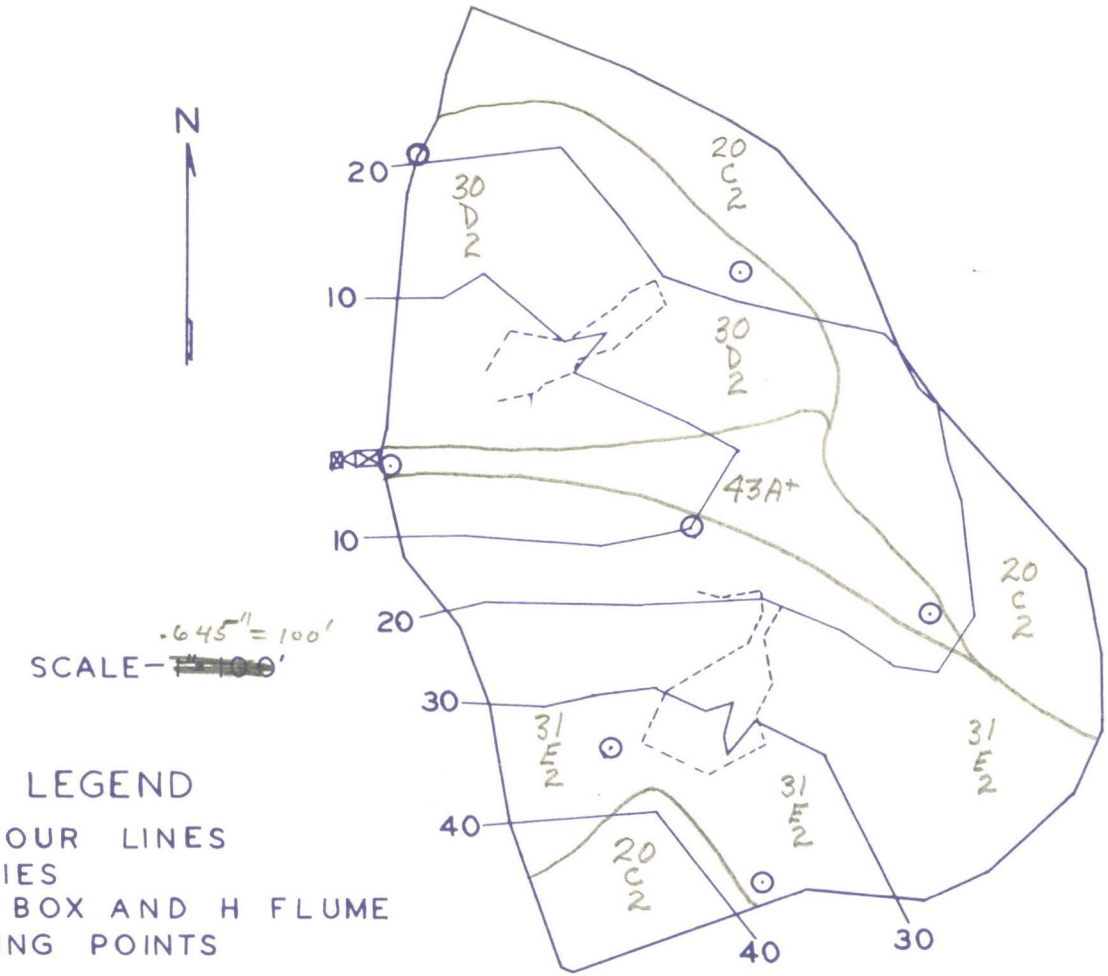
The costs below do not include the Project's technical staff time nor the labor expended in constructing the flumes.

Installation costs

3--recording rain gages	$ 846
7--Forest Service rain gages	60
5--ADR water-stage recorders	2500
5--Floats, tapes, weights, etc.	128
5--Coshocton samplers, divisors, collection cans, and mounting brackets	965 1/
5--H-type sheet metal flumes	3090
5--Complete approach sections	795
Excavation and concrete transport	609
Culverts	366
Power line	3200
5--Water-stage recorder shelters	125
Installation of electrical outlets	174
Drainage ditch excavation	80
	$12,938

1/ The divisors and collection cans were reworked several times.

APPENDIX



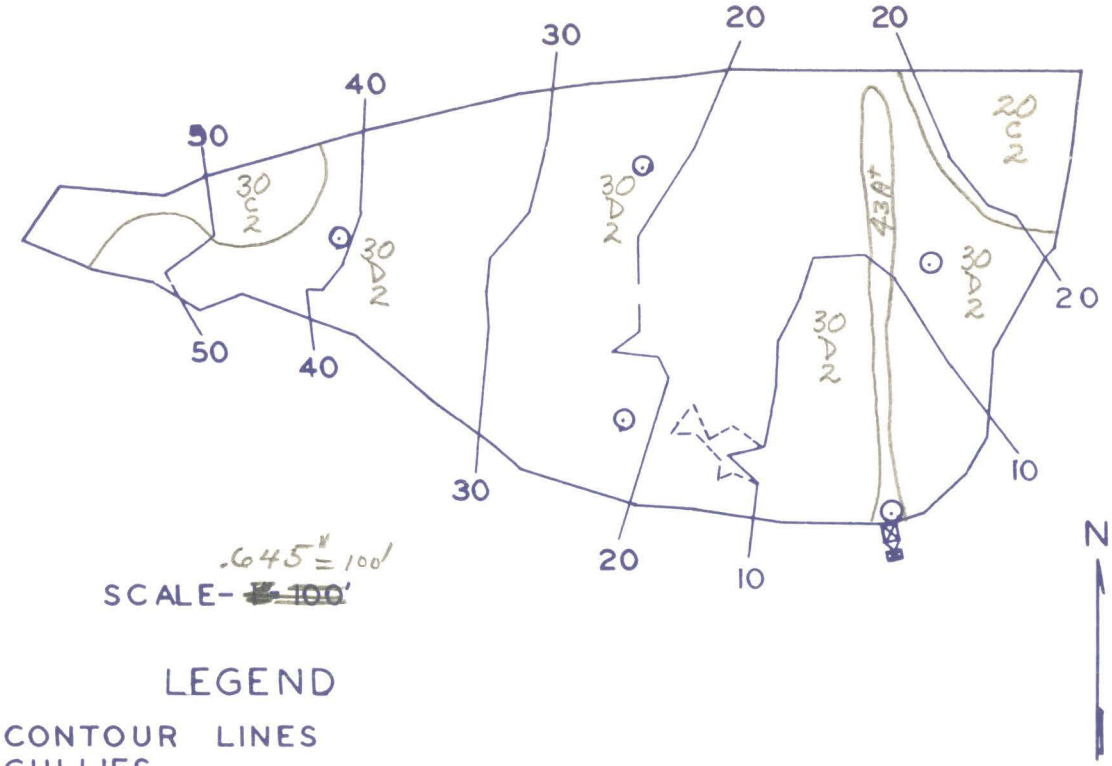
LEGEND

—— CONTOUR LINES
- - - - GULLIES
⊠ DROP BOX AND H FLUME
⊙ TURNING POINTS

DRAINAGE AREA
WATERSHED NO. I - 6.95 ACRES

COFFEEVILLE WATERSHED I

STUDY TH. 1.2
OXFORD RESEARCH CENTER
U.S. FOREST SERVICE



LEGEND

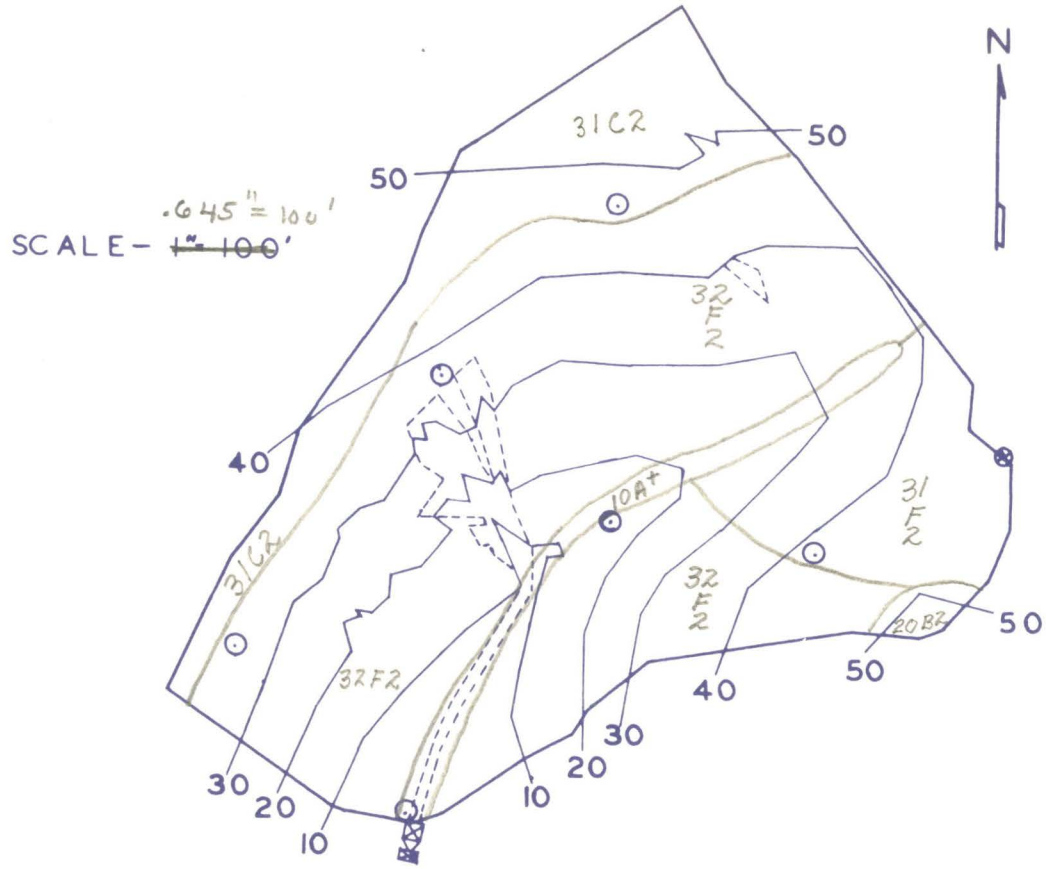
—— CONTOUR LINES
----- GULLIES
⊠⊠ DROP BOX AND H FLUME
⊙ TURNING POINTS

COFFEEVILLE WATERSHED II

STUDY TH 1.2
OXFORD RESEARCH CENTER
U.S. FOREST SERVICE

DRAINAGE AREA

WATERSHED NO. II – 4.77 ACRES



LEGEND

—— CONTOUR LINES
- - - - GULLIES
⊠⊠ DROP BOX AND H FLUME
⊙ TURNING POINTS
⊗ ELEVATION STAKE

COFFEEVILLE WATERSHED III

STUDY TH 1.2
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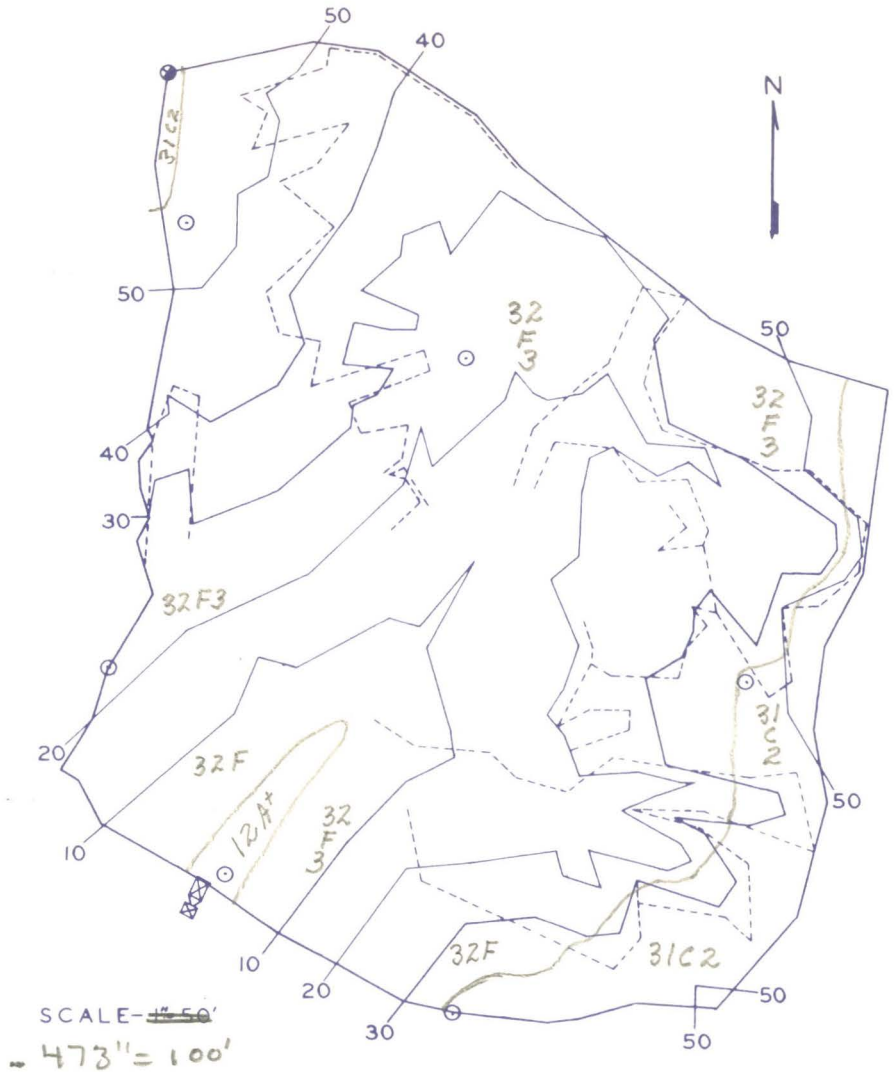
DRAINAGE AREA

WATERSHED NO. III – 5.91 ACRES



LEGEND

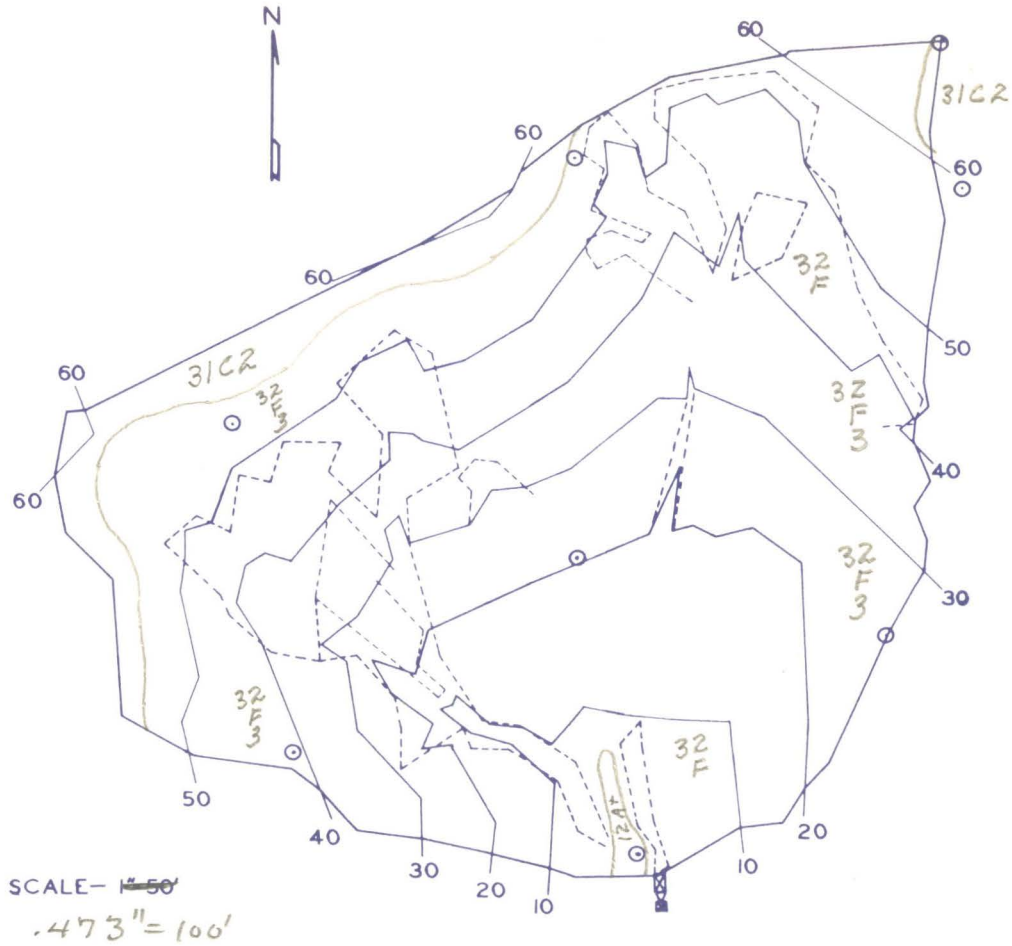
—— CONTOUR LINES
---- GULLIES
⊠⊠ DROP BOX AND H FLUME
⊙ TURNING POINTS
⊗ ELEVATION STAKE

COFFEEVILLE WATERSHED IV

STUDY TH 1.2
OXFORD RESEARCH CENTER
U.S. FOREST SERVICE

DRAINAGE AREA

WATERSHED NO. IV - 4.06 ACRES



LEGEND

—— CONTOUR LINES
---- GULLIES
⊠⊠ DROP BOX AND H FLUME
⊙ TURNING POINTS
⊗ ELEVATION STAKE

COFFEEVILLE WATERSHED V

STUDY TH 1.2
OXFORD RESEARCH CENTER
U.S. FOREST SERVICE

DRAINAGE AREA

WATERSHED NO. V – 3.67 ACRES

Table 6.--Cubic volume table for 1604-1.2--1963

D.B.H. (inches)	Merchantable length (feet)										
	5	10	15	20	25	30	35	40	45	50	55
	Cubic feet										
5		0.8	1.2	1.5							
6		1.4	1.7	2.1	2.5	2.8	3.1				
7		1.8	2.3	2.8	3.4	3.7	4.1	4.6	5.0		
8			3.5	4.1	4.8	5.3	6.1	6.7	7.5		
9			4.2	5.0	5.9	6.6	7.5	8.2	9.1	9.8	
10		3.8	5.1	6.0	7.0	7.9	8.8	9.7	10.6	11.6	12.5
11				7.9	9.1	10.4	11.6	12.7	14.0	15.1	16.4
12				9.0	10.5	12.0	13.3	14.6	15.9	17.1	18.5
13				10.2	11.9	13.6	15.2	16.5	18.1	19.3	20.7
14				11.4	13.2	15.0	16.8	18.6	20.1	21.7	22.9
15				12.6		16.6					
16				13.8		18.1					

Table 7.--Lesser vegetation plot locations on Watershed No. I

From survey stake number	Go		To hexagon center	Thence		To plot center
	Bearing	Distance	Number	Azimuth	Distance	Number
0	S68°E	105'	31	98°	32'	1
				257°	41'	2
	N31°E	125'	30	274°	5'	3
				290°	14'	4
2	S74°W	82-1/2'	27	187°	23'	5
				280°	14'	6
	S13°E	82-1/2'	19	195°	38'	7
				312°	7'	8
3	N60°W	37'	14	230°	19'	9
				255°	32'	10
	S60°E	75'	10	56°	41'	11
				323°	9'	12
	S19°W	100'	13	57°	34'	13
				79°	27'	14
4	N 0°	62-1/2'	22	106°	31'	15
				267°	13'	16
5	N61°E	24'	24	140°	10'	17
				323°	22'	18
6	N81°E	57-1/2'	20	52°	25'	19
				79°	40'	20

Table 8.--Losser vegetation plot locations on Watershed No. II

From survey stake number	Go		To hexagon center	Thence		To plot center
	Bearing	Distance	Number	Azimuth	Distance	Number
0	0°	0'	1	26°	34'	1
				40°	36'	2
	N60°W	112'	11	155°	41'	3
				351°	27'	4
1	N32°W	45'	3	10°	43'	5
				233°	16'	6
	N11°W	150'	4	84°	25'	7
				171°	44'	8
	S89-1/2°W	132-1/2'	10	30°	13'	9
				281°	31'	10
2	N82°E	95'	9	62°	19'	11
				260°	18'	12
	N 3°W	67-1/2'	15	241°	14'	13
				100°	27'	14
3	N86°W	157'	36	294°	34'	15
				307°	40'	16
4	S79°W	87-1/2'	22	93°	7'	17
				66°	28'	18
	N41°W	128'	21	92°	4'	19
				175°	41'	20

Table 9.--Lesser vegetation plot locations on Watershed No. III

From survey stake number	Go		To hexagon center	Thence		To plot center
	Bearing	Distance	Number	Azimuth	Distance	Number
1	N34°E	65'	20	61°	27'	1
				290°	4'	2
	S85°W	62-1/2'	25	172°	14'	3
				243°	24'	4
2	N73°E	142-1/2'	32	156°	26'	5
				264°	21'	6
	N21°E	105'	36	130°	8'	7
				139°	17'	8
3	S87-1/2°E	72-1/2'	26	7°	36'	9
				79°	27'	10
	N25°W	60'	30	140°	16'	11
				188°	17'	12
4	S71°W	67-1/2'	27	19°	15'	13
				186°	40'	14
5	S64°E	82-1/2'	10	283°	10'	15
				359°	9'	16
	N52°W	32-1/2'	14	176°	27'	17
				255°	14'	18
	N20°E	207'	8	153°	9'	19
				131°	44'	20

Table 10.--Lesser vegetation plot locations on Watershed No. IV

From survey stake number	Go		To hexagon center	Thence		To plot center
	Bearing	Distance	Number	Azimuth	Distance	Number
0	N86-1/2°E	99'	12	105°	23'	1
				309°	13'	2
	N39°E	156'	13	129°	35'	3
				304°	39'	4
2	S 9°E	100'	1	280°	20'	5
				288°	27'	6
	N47°E	22-1/2'	2	295°	34'	7
				323°	40'	8
	N6-1/2°E	130'	3	118°	34'	9
				129°	32'	10
	N48-1/2°W	112'	12	35°	1'	11
				238°	44'	12
	S62°W	94'	11	67°	1'	13
				335°	27'	14
3	S32-1/2°W	60'	14	231°	21'	15
				337°	27'	16
4	S22°E	67-1/2'	20	20°	39'	17
				110°	34'	18
	N74°E	57-1/2'	19	116°	44'	19
				146°	36'	20

Table 11.--Lesser vegetation plot locations on Watershed No. V

From survey stake number	Go		To hexagon center	Thence		To plot center
	Bearing	Distance	Number	Azimuth	Distance	Number
0	N 0°	62-1/2'	22	8°	2'	1
				241°	36'	2
1	N90°W	37-1/2'	13	13°	28'	3
				172°	40'	4
	N18°W	122-1/2'	14	182°	36'	5
				227°	1'	6
2	S58-1/2°W	80'	24	124°	12'	7
				332°	7'	8
3	N55-1/2°W	15'	33	170°	1'	9
				357°	14'	10
4	N90°W	77-1/2'	36	129°	25'	11
				162°	44'	12
	N90°E	120'	25	114°	5'	13
				201°	12'	14
5	S20°E	92-1/2'	20	83°	17'	15
				147°	20'	16
	N48°E	42-1/2'	19	100°	27'	17
				186°	10'	18
6	S81-1/2°W	77-1/2'	15	85°	41'	19
				281°	16'	20